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N 68-26893

18. VOLTAGE BREAKDOWN IN AN EXPLODING BRIDGE WIRE SYSTEM

W. H. Brown
Manned Spacecraft Center
National Aeronautics and Space Administration
Cape Kennedy, Florida

The exploding bridge wire (EBW) is an electronic system currently used on at least three major space boosters. The system is a method for initiating a pyrotechnic chain that departs from the classical hot wire system used for many years in the past and still used in many pyrotechnic systems.

The typical EBW system uses a low-voltage (24 v), low-current trigger system to initiate the chain reaction that results in the final pyrotechnic action. The trigger pulse acts to release an energy source in the form of a high-dc-voltage pulse of over 2,000 v, which ultimately causes a bridge wire to explode in the presence of a pyrotechnic charge. The 2,000-v source is generated by a transistorized circuit which converts 24 v dc to the 2,000 v needed in the bridge wire in the form of a short-duration pulse. A typical circuit is illustrated by Fig. 18-1.

The high-voltage pulse is transferred from the electronic packaging to the pyrotechnic detonator through a connector, P2. The connector is considered necessary so that the system may be broken and left in a safe condition before the intended use. The safe condition consists of a shorting plug connected at the detonator. This connector, in normal use, necessarily must pass high voltage without any degrading effects. A known flight failure occurred in one of the systems that used a conventional two-pin connector for this in-line connector. An immediate fix was made on the flight system by packing the connection with Dow Corning DC-4. The higher dielectric at the source of breakdown temporarily relieved the problem. The ultimate solution was a redesign of the disconnect system which would properly pass a high-voltage, short-duration pulse.

The new design was incorporated in the pyrotechnic detonator and consisted of a coaxial connector given a high-voltage rating of 2050 v. Such a detonator is made by the Dage Electric Company, Franklin, Indiana. The detonator contains the pyrotechnic charge, which is the first operation in the ordnance chain reaction. The pyrotechnic charge is detonated by the bridge wire, which explodes when the high-voltage pulse is applied to the bridge wire. In series with the center conductor between the connector and the bridge wire is a voltage breakdown gap. This gap prevents a low voltage, incapable of bridging the gap, from exploding the bridge wire.

For reference, the Dage Electric Company detonator has been described. It is known as PS-9710 modified; or the right-angle type is known as PS-9668 modified. Such a detonator has proven to be reliable when incorporated in the system for which it was intended. Figure 18-2 illustrates the connector and detonator.

The referenced high-altitude flight failure occurred at the two-pin connector used in the original system design. The failure mode was resolved to be high voltage breakdown between the two pins of the connector. A standard connector has no means of retaining pressure nor releasing pressure so that it is not known what pressure was present at the time the failure occurred.

It is the nature of the EBW firing unit that one high voltage pulse is available after the unit is armed. One 28-v-dc trigger is expected to serve to provide the high-voltage pulse for exploding the bridge wire. This output pulse from the EBW firing unit is intended to be of sufficient magnitude to jump a gap within the detonator to reach the bridge wire. The gap is evident in Fig. 18-2 as a break in the center conductor.

The coaxial connector design is very similar to a BNC coaxial connector. Such a design gives high voltage carrying capability as well as allowing good isolation from extraneous noises such as radiated radio energy. A coaxial connector carries the system wiring shield continuously through the connector.

It is intended that this information will serve to illustrate a point of failure in an otherwise safe and reliable system. A weak point need only be found and the failure mechanism understood before a cure is short in coming.

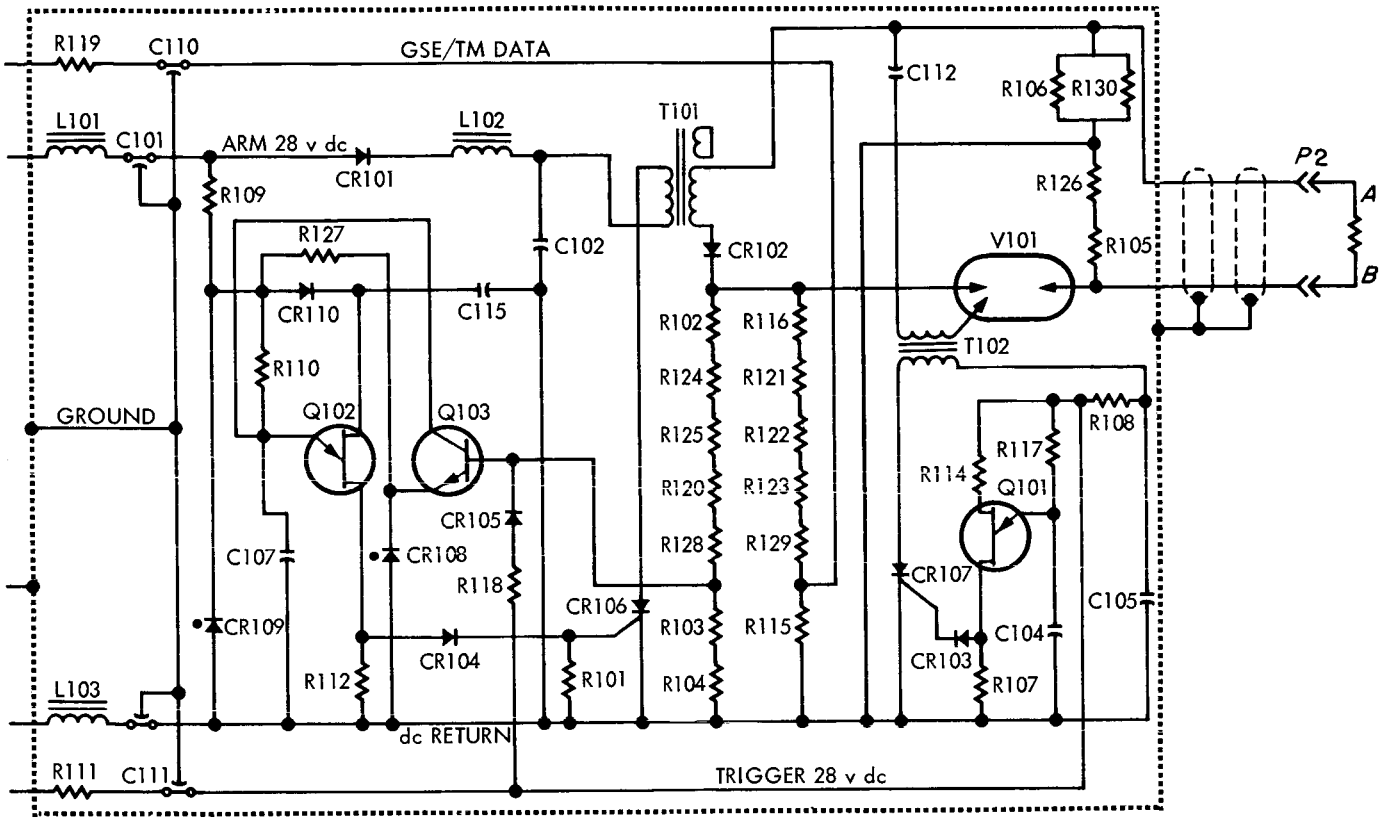

Fig. 18-1. EBW firing unit

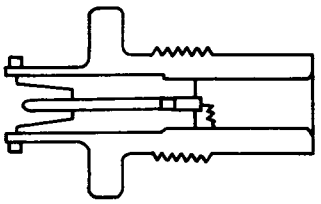

Fig. 18-2. Pyrotechnic detonator with coaxial electrical connection